Materials and Structural Analysis
Aeroelasticity and Design Optimization

Research Areas

- Finite Element Modeling
- Flutter and Limit Cycle Oscillation
- Aero-Structural Sensitivities
- Analytical Certification

Overview

Research to develop new computational algorithms will make possible efficient analysis and design optimization of accurate aeroelastic models. Aeroelasticity—that is, the analysis of aerodynamic performance of flexible aircraft—is important to high performance military aircraft, such as manned fighters and certain uninhabited aerial vehicles that are designed for long loiter times or high-g maneuvers. Aeroelastic design of such vehicles is complicated by the interdisciplinary coupling between the aerodynamic loads on the vehicle and flexible response of the structure to those loads.

Recent Findings

Comparative studies of flutter predictions using transonic aerodynamic theory with flight test results for an F-16 with stores are identifying the critical modeling issues for accurate predictions.

Approach

Cost savings in the acquisition of military systems can be realized by a transition from purely experimental certification of components and sub-systems to increased reliance on analytical certification. Confidence in this new approach depends on quantifying the uncertainty in the simulation models and results. Future research will do so for certification of F-16 store configurations and a futuristic "sensor-craft" model.

Several system studies have suggested the joined wing aircraft as a candidate for an uninhabited aerial vehicle (UAV) sensor-craft that can carry large antennas for high altitude surveillance. Engine efficiency, aircraft empty weight, and high lift-to-drag are important features of this design, because this aircraft must loiter on station for long periods of time. Computational methods will be developed to optimize the sensor-craft design, including aeroelastic effects.

For further information, please contact:

Lt Col Bob Canfield,
Assistant Professor
(937) 255-3636 x4641 (DSN 785)
Robert.Canfield@afit.edu

Materials and Structural Analysis
Analysis of Aerospace Structures

Research Areas

- Finite Element Model Updating
- System Identification
- Eigenstructure Assignment
- Damage Detection

Recent Findings

Using resonant and anti-resonant frequencies to update finite element models of the flexible truss apparatus described below, AFIT researchers were able to improve model correlation by 46%. The improved model was used to show that synthetic damage detection is feasible. Researchers here also recently improved damage detection algorithms using anti-resonant frequencies to 99+% accuracy.

Experimental Facilities

A six meter cantilevered aluminum truss with bolt-in Lexan diagonals is available along with two proof-mass actuators, accelerometers, and a Scientific Atlanta analyzer. MATLAB and other software applications can be used concurrently for real-time vibration control and/or post-processing of data.
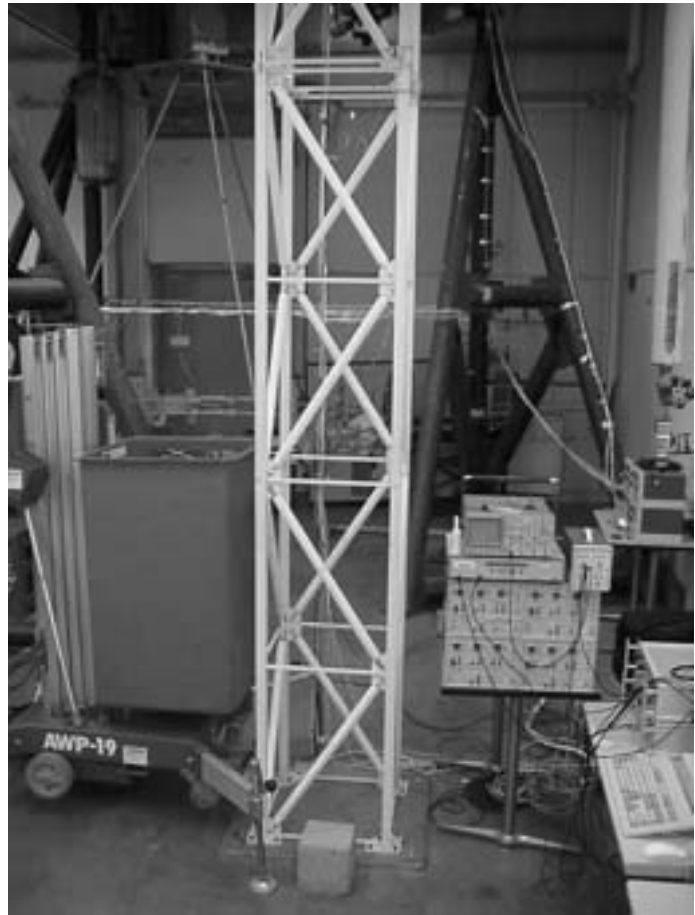
Flexible Truss Experiment (donated by AFRL/VA)
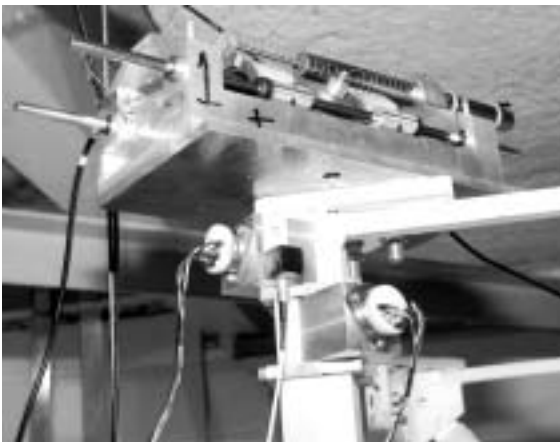
Proof-Mass Actuator

For further information or to suggest a related thesis topic, please contact:

Dr Brad Liebst, Professor and Head
(937) 255-3069 (DSN 785)
Bradley.Liebst@afit.edu

Lt Col Bob Canfield, Assistant Professor
(937) 255-3636 x4597 (DSN 785)
Bob.Canfield@afit.edu

Materials and Structural Analysis
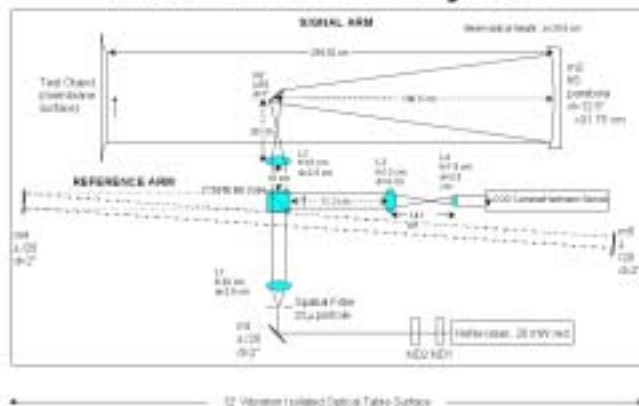## Membrane Optics Laboratory

Research Areas

- Space Optics
- Adaptive Structures
- Inflatable Structures

Recent Findings

Performed basic research into the fabrication and testing of adaptive membrane optical systems. Constructed several 6 in. dia. flat optical membranes. This research into the active control of adaptive optical membranes will allow gossamer (> 10m) space-based optics for various DoD and NASA missions.

Sample 6 inch Membrane Mirror

Experimental Facilities

WaveLab wavefront sensor, 12 in. diameter Twyman-Green Interferometer. High Voltage amplifiers for adaptive structures research. A 4'x12' isolated optical table. A fixed and scanning laser vibrometer along with standard modal testing instrumentation. MATLAB and other software applications can be used concurrently for vibration testing and/or post-processing of data.

For further information or to suggest a related thesis topic, please contact:

Dr Brad Liebst
Professor and Head
(937) 255-3069 (DSN 785)
Bradley.Liebst@afit.edu

Maj Greg Agnes
Assistant Professor
(937) 255-6565 x4317
Gregory.Agnes@afit.edu

Interferometer Layout

Optical Testing of Membrane Surfaces

Materials and Structural Analysis
Structural Analysis

Research Area

- Finite element analysis
- Plate and shell vibration analysis
- Nonlinear geometric considerations
- Through the thickness stress and displacement considerations
- High energy impact
- Material failure representation

Recent Findings

The characteristics of composite sandwich plate response under impact has been successfully modeled and compared to experimentation (see Figures). The material failure algorithms have been extended for the development of an understanding to the gouging phenomenon found in the Holloman AFB High Speed Vehicle Study.

Facilities Used

The MSRC computer system and the in-house SUN workstation have been used. In-house FORTRAN Finite Element codes have been applied as well as Hydroram high velocity impact codes.

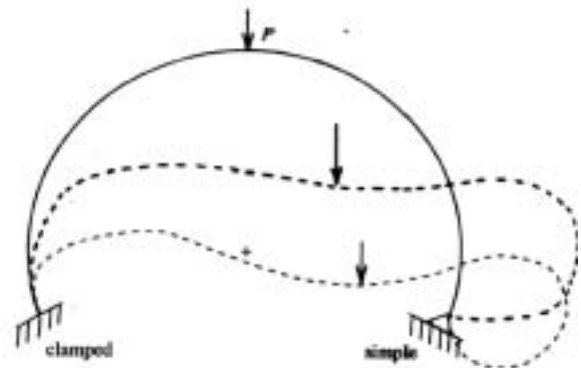*For further information or to suggest a related thesis topic, please contact:*

Dr Anthony N. Palazotto
Professor of Aerospace Engineering

(987) 255-3636 x4599 (DSN 785)
Anthony.Palazotto@afit.edu

High-Speed Impact
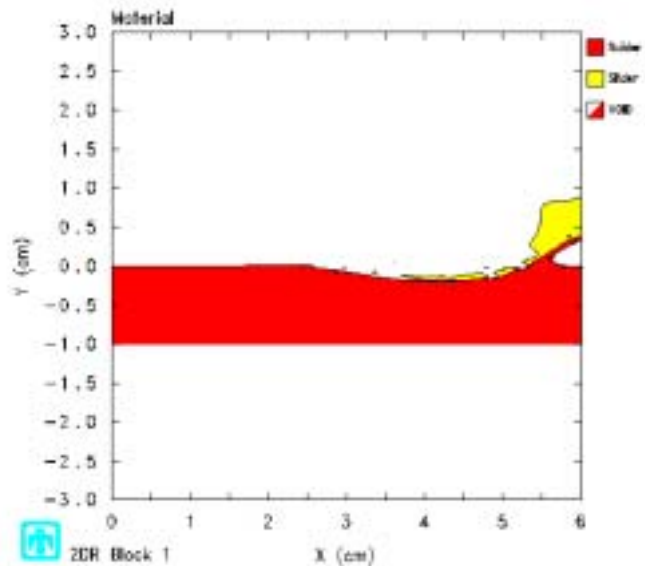
Deep Isotropic Arch Deformation

Advances Under the Current Research

- A New and Useful Tool (2-D FE Code)
  - very general application vis-a-vis geometry and anisotropy
  - goes beyond component level
- Layer-Wise Displ. Functions Evaluated and Improved
- New C^t (44 DOF) Finite Element Developed
- Hi-Fi Cross-Section Modeling for Shell of Revolution
- Inflation of Complex Geometry and Contact
  - Quasi-3D Results from 2-D Model

Materials and Structural Analysis
Vibration, Damping, and Controls Laboratory

Research Areas
- Adaptive Structures
- Modal Testing
- Inflatable Structures
- Mode Localization

Recent Findings

Using analysis and modal testing researchers were able to validate statistical models of mode localization in aerospace structures as part of an ongoing effort to reduce High Cycle Fatigue of turbo machinery. Currently, research into the active control of adaptive inflatable tubes will allow gossamer (> 25m) space antennae for various DoD and NASA missions.

Experimental Facilities

Two HP Spectrum analyzers with 48 channels of data input plus tachometer. Two 20in/8out dSpace real-time controllers. High Voltage amplifiers for adaptive structures research. A 4'x8' isolated granite vibration testing table. A 5' x 3' dia. Vacuum chamber. A fixed and scanning laser vibrometer along with standard modal testing instrumentation. MATLAB and other software applications can be used concurrently for real-time vibration control and/or post-processing of data.

Forced Response Testing of a Bladed-Disk Test Article

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Gregory.Agnes@afit.edu

Modal Testing of 6-rib Antennae Model